GAMMA-RAY LARGE AREA SPACE TELESCOPE (GLAST) PROJECT

GLAST BURST MONITOR (GBM) INSTRUMENT – SPACECRAFT INTERFACE REQUIREMENTS DOCUMENT

May 3, 2002

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

GAMMA-RAY LARGE AREA SPACE TELESCOPE (GLAST)

PROJECT

GLAST BURST MONITOR (GBM) INSTRUMENT – SPACECRAFT

INTERFACE REQUIREMENTS DOCUMENT

May 3, 2002

NASA Goddard Space Flight Center

Greenbelt, Maryland

GLAST PROJECT GBM INSTRUMENT – SPACECRAFT IRD

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ACRONYM LIST

ACS	Attitude Control Subsystem
bps	bits per second
BGO	bismuth germinate
C&DH	Command and Data Handling
CCSDS	Consultative Committee for Space Data Systems
CTDB	Command, Telemetry and Data Bus
Dec	Declination
DPU	Data Processing Unit
EMI	Electromagnetic Interference
FOV	Field of View
g	gravity
GBM	GLAST Burst Monitor
GEVS-SE	General Environmental Verification Specification for SDTS and ELV Payloads, Subsystems and Components
GLAST	Gamma-ray Large Area Space Telescope
GPS	Global Positioning System
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
Hz	Hertz
IGES	International Graphics Exchange Specification
IR	Infrared
IRD	Interface Requirements Document
ICD	Interface Control Document
k	kilo
kg	kilogram
LAT	Large Area Telescope
m	meter
M	Mega
Mil Std	Military Standard
MLI	Multi Layer Insulation
PAF	Payload Attach Fitting
PDR	Preliminary Design Review
PMT	photomultiplier tubes
PPS	Pulse Per Second
RA	Right Ascension
SC	Spacecraft
SI	The International System of Units
sr	Steradian
SRD	Science Requirements Document
TBC	To Be Confirmed
TBD	To Be Determined
TBR	To Be Resolved
TDRSS	Tracking and Data Relay Satellite System
TBS	To Be Supplied
UTC	Universal Coordinated Time
UV	Ultra Violet
V	Volt
W	Watt

1 INTRODUCTION

1.1 PURPOSE

The primary purpose of this Interface Requirements Document (IRD) is to describe and specify the interfaces between the GLAST Burst Monitor (GBM) instrument and the SC. However, it also provides the launch vehicle constraints on these system elements and provides design guidelines in certain areas. Environmental estimates for radiation and micrometeoroids are specified in the GLAST Mission System Specification (433-SPEC-0001). In addition, it assigns certain interface responsibilities.

1.2 RELATION TO OTHER DOCUMENTS

The requirements in this document normally flow down directly to instrument and SC systems from either the GLAST Science Requirements Document (433-SRD-0001) or the GLAST Mission System Specification (433-SPEC-0001). In addition, either the GBM Requirements Database (GBM-REQ-1007) or the GLAST Spacecraft Performance Specification (433-SPEC-0003) may levy peer requirements.

2 APPLICABLE DOCUMENTS

The following documents are applicable:

GLAST Science Requirements Document (433-SRD-0001)

GLAST Mission System Specification (433-SPEC-0001)

GLAST Spacecraft Performance Specification (433-SPEC-0003)

GLAST Observatory Electromagnetic Interference (EMI) Requirements Document (433-RQMT-0005)

GLAST Mission Assurance Requirements (MAR) for the GBM (433-MAR-0002)

GBM Requirements Database (GBM-REQ-1007) (NOTE: In the event of conflict, this IRD takes precedence)

Delta II Payload Planners Guide, MDC 00H0016, October 2000, http://www.boeing.com/defense-space/space/delta/docs/DELTA_II_PPG_2000.PDF

GEVS-SE Rev A General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components, June 1996, http://arioch.gsfc.nasa.gov/302/gevs-se/toc.htm

CCSDS 102.0 B 5, "Recommendation for Space Data Systems Standards. Packet Telemetry." CCSDS Recommendation, Blue Book, November 2000.

Mil-STD-1553B, Aircraft Internal Time Division Command/Response Multiplex Data Bus, 21 September, 1978

NASA HDBK 4001, Electrical Grounding Architecture for Unmanned Spacecraft, February 17, 1998
http://starbase.msfc.nasa.gov/TSL/dispsearch.htm?agency=NASA&disp=E

3 REQUIREMENTS

3.1 DEFINITION OF FLIGHT SYSTEM

3.1.1 SYSTEM MODULES

There are three major system modules in the GLAST flight system, a SC module, a Large Area Telescope (LAT) module, and a GLAST Burst Monitor (GBM) module, as shown in Figure 3-1. Different contractors will build these modules separately. When integrated, these modules form the GLAST observatory. This document defines the SC interfaces for the GBM. The GBM sensors are illustrated as four, periphery sensors along the bottom of the LAT instrument. However, the GBM actually consists of 12 NaI detectors and 2 BGO detectors. Also shown in this figure, is the coordinate system for the observatory.

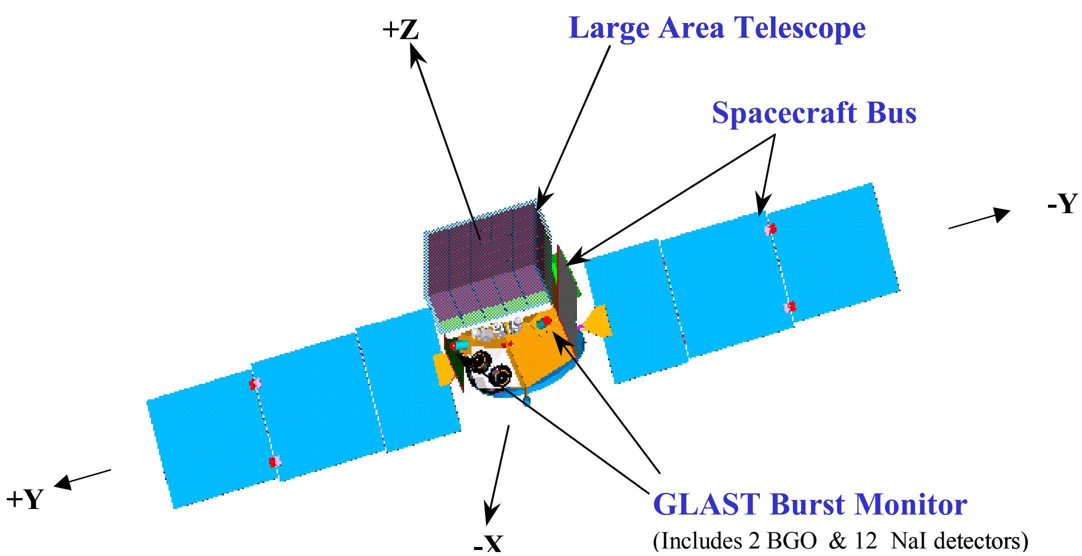


Figure 3-1 Flight System Modules

3.1.2 FLIGHT SYSTEM INTERFACES

The flight system is defined as “everything that flies”, instruments, SC, and launch vehicle. Figure 3-2 shows these components of the flight system and the interfaces between them. It also shows that the flight system has in-flight interfaces with the TDRSS communications satellite system, with direct ground stations, and with the constellation of GPS satellites. Arrows are used in the figure to indicate generally an accommodation requirement. The SC must directly accommodate the launch vibration environment, fairing envelope, and mounting configuration of the payload attach fitting. While on the launch pad, it receives umbilical power and communicates through the umbilical for command and telemetry.

The instruments also have direct interfaces with the launch vehicle in that they must accommodate the launch environment (acoustics, pressure, and temperature) and the fairing envelope. The SC must accommodate the instruments’ mechanical mounting and field of view requirements, as well as their thermal interface requirements. Additionally, the SC provides power services and command and telemetry services to the instruments. Although an overview of the SC interfaces is given, only the specific SC interfaces, which pertain to the GBM, are addressed in this document.

The data transfer and command interfaces between the LAT and the GBM instruments are implemented via the SC's C&DH subsystem. Excluding a GBM "burst trigger" signal, which interfaces to the LAT through the SC wiring harness, all data sent from the GBM instrument must first pass through the C&DH subsystem. The C&DH subsystem shall determine where and when the GBM instrument's data shall be sent. The SC interfaces with direct ground stations for the downlink of high rate telemetry data. It interfaces with TDRSS when communications are needed at unscheduled times or when coverage is needed over a greater portion of the orbit than the direct downlink provides. The demand access service of TDRSS is used for unscheduled alert transmissions, both safe mode and transient events, and for unscheduled target-of-opportunity commanding. Extended coverage is needed during launch and early orbit operations, during any safe mode contingency operations, and for servicing the science instruments (diagnostics, software uploads).

Finally, the SC receives time and position services continuously throughout the mission from the GPS. The SC distributes a pulse-per-second signal via hardwire to provide an accurate time mark.

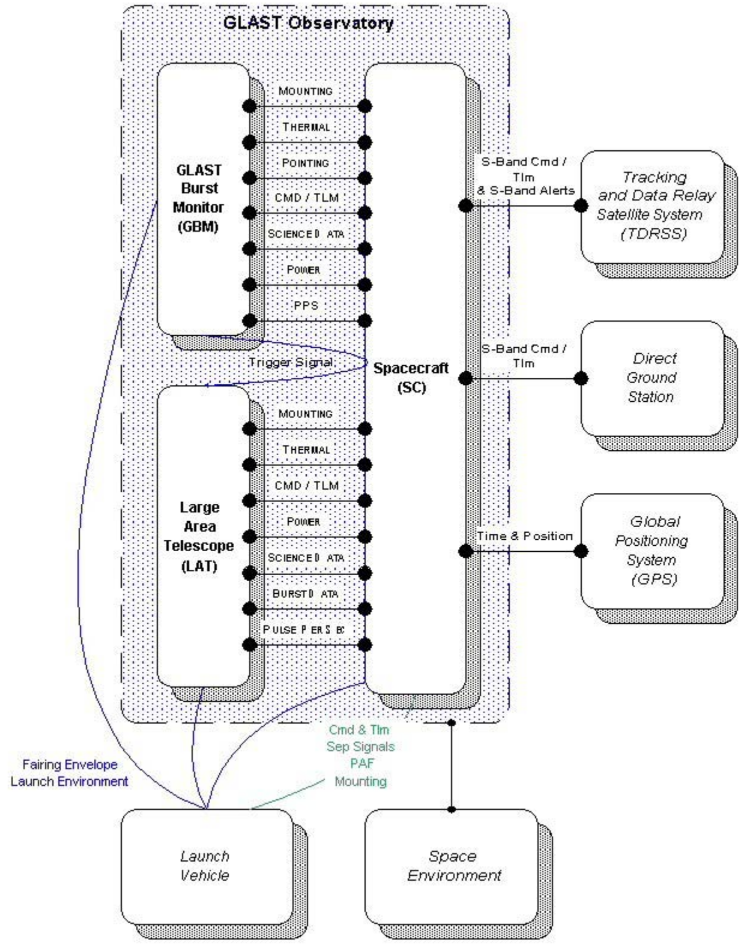


Figure 3-2 Flight System Interfaces

3.2 INTERFACE REQUIREMENTS AND CONSTRAINTS

3.2.1 GENERAL INTERFACE REQUIREMENTS

3.2.1.1 Axes Definitions

The GBM shall use the body-fixed coordinate system, defined below.

3.2.1.1.1 Body-Fixed Coordinate System

The observatory body-fixed coordinate system shall be as specified in the GLAST Mission System Specification (433-SPEC-0001).

Note: The observatory will use a right-handed coordinate system fixed in the observatory body, as shown previously in Figure 3-1. The origin of the body-fixed coordinate system lies in the separation plane of the launch vehicle Payload Attachment Fitting (PAF). The +Z direction lies along the center of the LAT field of view. The Y-axis will be parallel to the solar array drive axes. The –X-axis will be the anti-sun side. The +Y-axis will be the cross-product of the +Z-axis and the +X-axis. The terms Roll axis, Pitch axis, and Yaw axis refer to the X, Y, and Z observatory axes, respectively.

3.2.1.2 Inertial Coordinate System

GLAST shall use the inertial coordinate system specified in the GLAST Mission System Specification (433-SPEC-0001).

NOTE: GLAST will use the J2000 inertial coordinate system.

3.2.1.2.1 Right Ascension (RA) and Declination (DEC)

RA and DEC shall be used as specified in the GLAST Mission System Specification (433-SPEC-0001).

NOTE: RA and DEC will be used as a standard means of receiving and communicating pointing directions

3.2.1.3 Pointing Knowledge

3.2.1.3.1 Pointing Knowledge Allocation

The GBM NaI detector pointing knowledge error budget shall be allocated as specified in the GLAST Mission System Specification (433-SPEC-0001).

NOTE: The relative alignment of the SC coordinate system and both the GBM NaI and BGO detectors cannot be calibrated on orbit.

3.2.1.4 Fairing Envelope Constraint

The fairing envelope constraints shall be followed as shown in the reference document, Delta II Payload Planners Guide for the 3-meter fairing, two-stage configuration (6915 PAF, with secondary latch system).

3.2.1.5 Ground Environmental Requirements

3.2.1.5.1 Ground Storage Temperature for the DPU and Power Box

The ground storage temperature for the DPU and Power Box shall not be less than -30 C and shall not exceed +70 C.

3.2.1.5.2 Ground Storage Temperature for the Detectors

The ground storage temperature for the detectors shall be -10 C to 45 C.

3.2.1.5.2.1 Ground Storage Temperature Rate of Change

The temperature rate of change for the detectors shall not exceed 8 C/hour.

3.2.1.5.3 Humidity

The relative humidity during ground testing shall not be less than 30% and shall not exceed 70%.

3.2.1.6 Units of Measurement

GBM shall observe the current NASA policy directive, NPD 8010.2C, Use of the Metric System of Measurement in NASA programs.

3.2.1.7 Exceptions

Metric units shall be used with the following exceptions: Angular measure may be expressed in degrees, minutes, and seconds; Photon and particle energy may be expressed in eV; and English units may be used for mechanical fabrication.

3.2.2 MECHANICAL

3.2.2.1 Envelope of GBM

Preliminary DPU, Power Box, BGO Detector, and NaI Detector envelopes are illustrated in the appendix.

NOTE: Dimensions are preliminary and SC accommodation needs to provide for a minimum of 20% growth.

3.2.2.2 Math Models

Mathematical models shall be readily exchanged electronically between the GBM Project and SC contractors and the GSFC.

3.2.2.2.1 Formats

This shall require the use of common design tools and versions for file format compatibility. Alternate formats shall be acceptable only when approved by the GLAST Project Office.

3.2.2.2.2 Mechanical Design Information Exchange

Exchange of mechanical design information shall primarily use the IGES neutral file format (bounded surface models).

NOTE: Other formats, such as STEP file format, may also be required.

3.2.2.2.3 Math Model Units

SI units shall be used in the Math Models.

3.2.2.3 GBM Mounting

3.2.2.3.1 Mounting Hardware

The SC shall provide mounting hardware for the GBM system. The term “GBM interface plane” is defined as the SC to GBM NaI detector mechanical interface plane for an individual NAI detector. There is one GBM interface plane for each of the 12 NaI detectors.

3.2.2.3.1.1 GBM Mounting Hardware Mass

The GBM system's mounting hardware mass shall be included in the SC mass allocation.

NOTE: The GBM system consists of all NaI detectors, BGO detectors, flight harnessing (provided by the SC), and electronic boxes.

3.2.2.3.2 NaI Detectors: Mounting with FOV requirements

In the deployed configuration on-orbit and during ground testing, the direction to any point in the sky within 120 degrees of the +Z axis shall be <80 degrees from the GBM interface plane normal vectors of at least 3 unobstructed NaI detectors, with 95% probability; the goal is 4 unobstructed detectors with 100% probability.

NOTE: Solar arrays are not considered obstructions.

3.2.2.3.2.1 NaI Detector Normal Vector Separation

The angle between the GBM interface plane normal vectors of any two NaI detectors shall be >25 degrees.

3.2.2.3.3 BGO Detectors: Mounting with FOV requirements

In the deployed configuration on orbit and during ground testing, at least one unobstructed BGO detector shall be visible from any point in the sky within 120 degrees of the +Z axis, with 95% probability (the goal is 100% probability over all directions).

NOTE: Solar arrays are not considered obstructions.

3.2.2.3.3.1 BGO Detector Mounting Interface CH-04

The BGO detectors shall have a 3-point mounting interface.

3.2.2.4 Cable Routing

The SC shall accommodate the routing of all GBM flight harnesses.

3.2.2.5 GBM Mass Constraint

The maximum launch mass of the GBM shall be constrained to 115 kg. CH-12

NOTE: The GBM launch mass includes all GBM detectors and electronics boxes.

3.2.2.5.1 GBM Flight Harness Mass

The GBM flight harness mass shall be included in the SC mass allocation.

3.2.2.6 Center of Gravity

The SC shall accommodate the center of gravity locations of the GBM.

3.2.2.7 Alignment

The alignment of each GBM NaI detector shall support the GBM-SC system pointing knowledge budget specified in the GLAST Mission System Specification (433-SPEC-0001).

3.2.2.7.1 GBM Alignment Reference Surface

Each GBM detector shall have a reference reflector surface normal vector for use in defining the alignment of the crystal axis.

3.2.2.7.2 Internal GBM NaI Detector Crystal Axis Misalignment

The internal GBM NaI misalignment of a detector crystal axis relative to its GBM detector reference reflector surface normal vector shall be < 3 arc minutes [1 sigma, radial]. CH-03

3.2.2.7.3 Internal GBM BGO Detector Crystal Axis Misalignment

The internal GBM BGO misalignment of a detector crystal axis relative to its GBM detector reference reflector surface normal vector shall be < 30 arc minutes [1 sigma, radial].

3.2.2.7.4 GBM BGO Detector Crystal Axis Alignment

The GBM BGO detector crystal axis alignment shall be 90 degrees to the observatory +Z axis to < 180 arc minutes [1 sigma, radial]. This vector shall be measured to an accuracy of <60 arc minutes [1 sigma, radial]. CH-04

3.2.2.8 Structural Design Requirements

3.2.2.8.1 Stiffness

The fixed base stiffness of all GBM components shall produce a first mode frequency greater than 50 Hz.

3.2.2.8.1.1 Test Demonstration

Test (e.g., low level sine vibration) results shall demonstrate compliance with the 50 Hz minimum frequency requirement. Low level sine vibration sweep shall extend to 150 Hz, in order to verify existence of any modes which may be influenced by the launch vehicle main engine cut off event. CH-014

3.2.2.8.2 Static Load Design

The design of the GBM mounting structure and GBM components shall use a limit load of ± 12.0 g applied to each axis independently. Verification of the strength of the GBM mounting structure and GBM components shall be done using the appropriate factors of safety for either testing or analysis only. Hardware subjected to strength qualification testing shall utilize a test factor of 1.25 (i.e. the test load is equal to the limit load x 1.25). CH-014

3.2.2.8.2.1 Factors of Safety

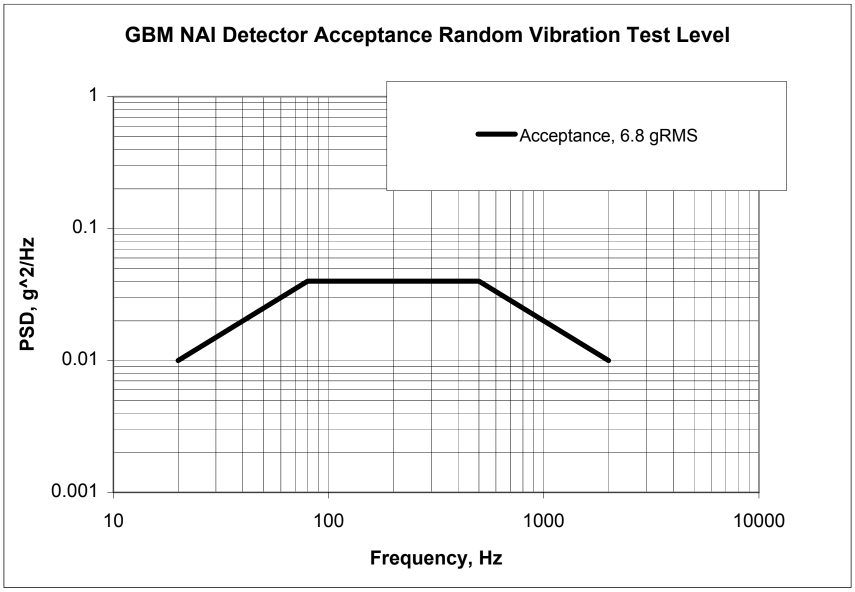
GBM shall use guidelines for the appropriate use of factors of safety given in the referenced GEVS-SE Rev A document.

NOTE: Factors of safety are multiplicative factors that are applied to limit loads to evaluate the yield and ultimate strength margins of the structural design. CH-014

3.2.2.8.3 Component Evaluation Random Vibration

3.2.2.8.3.1 NaI Detector Random Vibration Levels

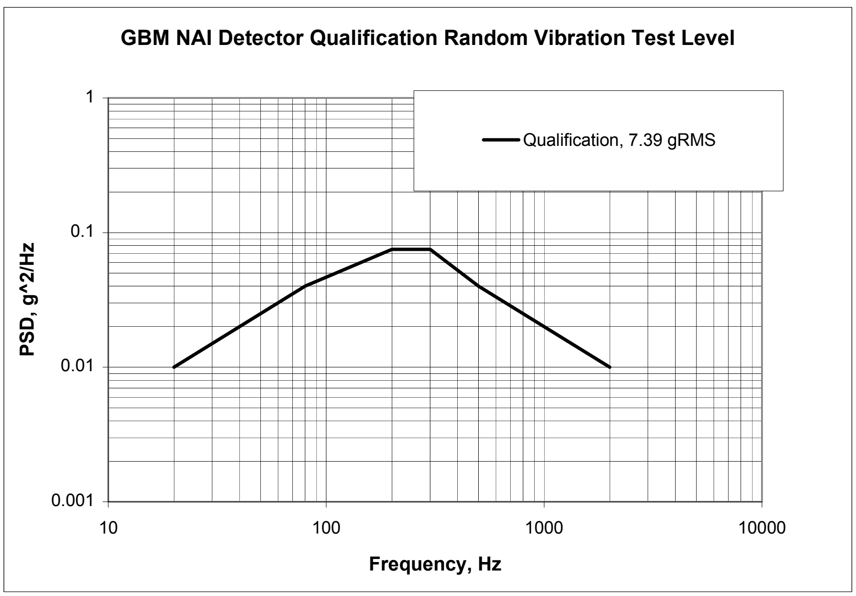
The evaluation of the NaI detectors shall use the acceptance and qualification random vibration test levels shown in Figure 3-3 . CH-014



NAI Detector
Acceptance Test Level

Frequency Hz	ASD g^2/Hz
20	0.01
80	0.04
500	0.04
2000	0.01
O/A	6.8

Duration: 60 secs/axis



CH-014

NAI Detector
Qualification Test Level

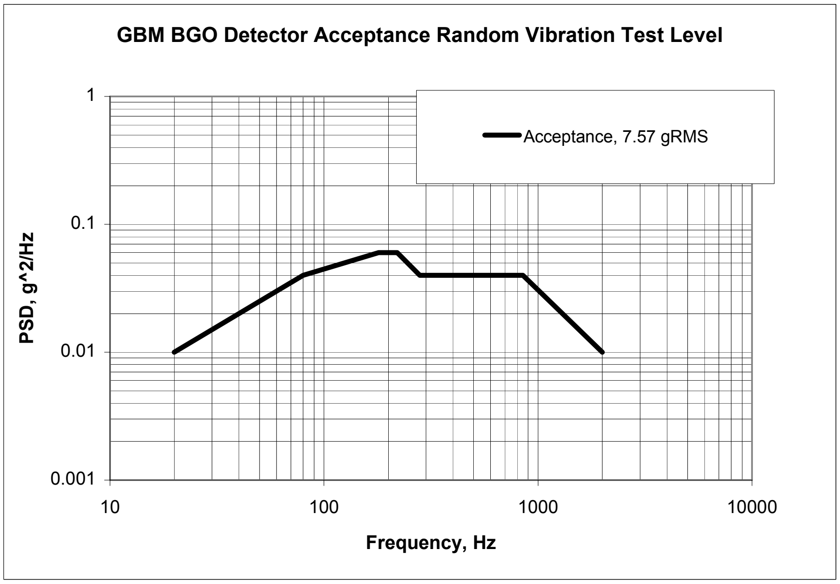
Frequency Hz	ASD g^2/Hz
20	0.01
80	0.04
200	0.075
300	0.075
500	0.04
2000	0.01
O/A	7.39

Protoflight Duration: 60 secs/axis
Prototype Duration: 180 secs/axis

Figure 3-3 NaI Detector Random Vibration Test Levels

3.2.2.8.3.2 BGO Detector Random Vibration Levels

The evaluation of the BGO detectors shall use the acceptance and qualification random vibration test levels shown in Figure 3-4.

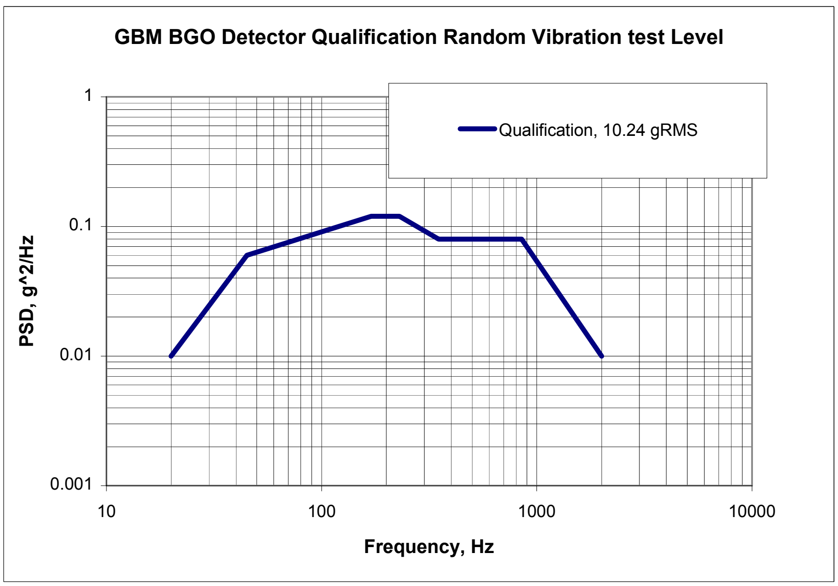


BGO Detector
Acceptance Test Level

Frequency Hz	ASD g^2/Hz
20	0.01
80	0.04
180	0.06
220	0.06
280	0.04
850	0.04
2000	0.01
O/A	7.57

Duration: 60 secs/axis

CH-014



BGO Detector
Qualification Test Level

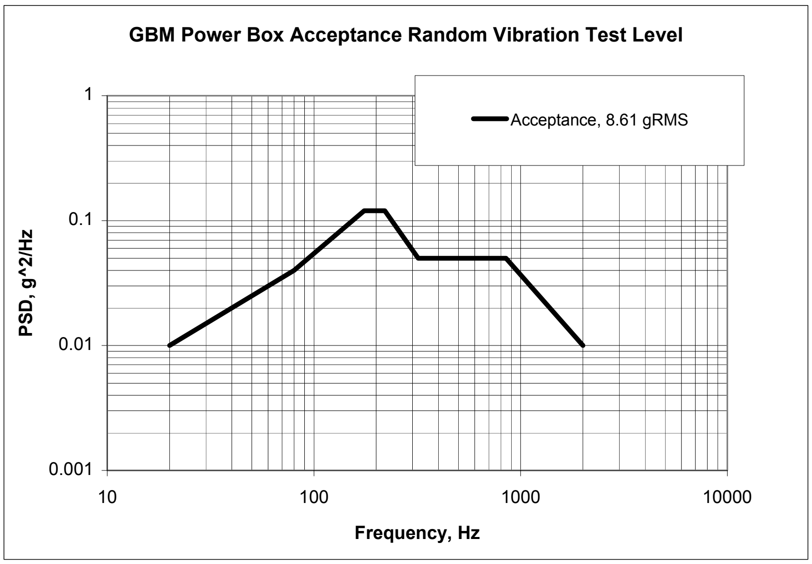
Frequency Hz	ASD g^2/Hz
20	0.01
45	0.06
170	0.12
230	0.12
350	0.08
850	0.08
2000	0.01
O/A	10.24

Protoflight Duration: 60 secs/axis
Prototype Duration: 180 secs/axis

Figure 3-4 BGO Detector Random Vibration Test Levels

3.2.2.8.3.3 Power Box Random Vibration Levels

The evaluation of the Power Box shall use the acceptance and qualification random vibration test levels shown in Figure 3-5.

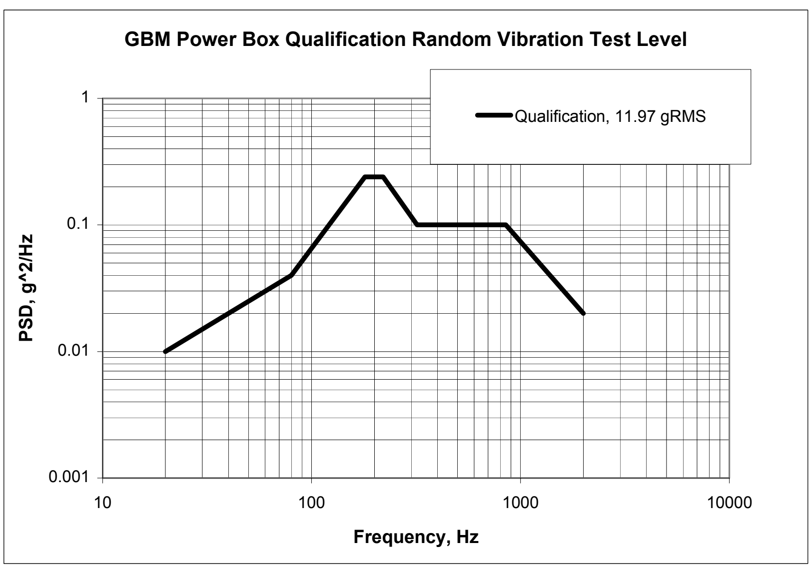


Power Box
Acceptance Test Level

Frequency Hz	ASD g^2/Hz
20	0.01
80	0.04
175	0.12
220	0.12
320	0.05
850	0.05
2000	0.01
O/A	8.61

Duration: 60 secs/axis

CH-014



Power Box
Qualification Test Level

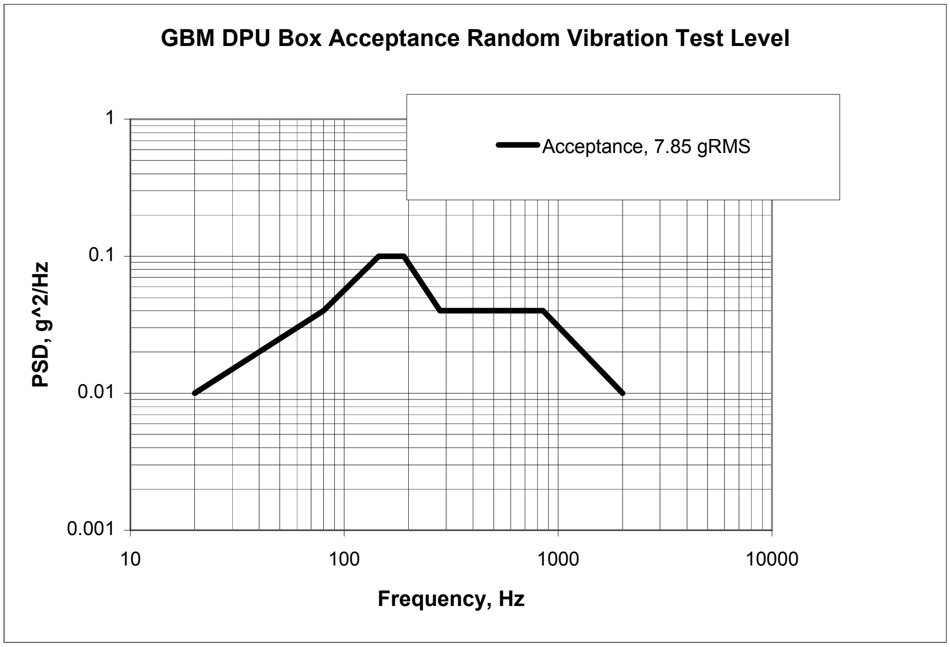
Frequency Hz	ASD g^2/Hz
20	0.01
80	0.04
180	0.24
220	0.24
320	0.1
850	0.1
2000	0.02
O/A	11.97

Protoflight Duration: 60 secs/axis
Prototype Duration: 180 secs/axis

Figure 3-5 Power Box Random Vibration Test Levels

3.2.2.8.3.4 DPU Random Vibration Levels

The evaluation of the DPU shall use the acceptance and qualification random vibration test levels shown in Figure 3-6.

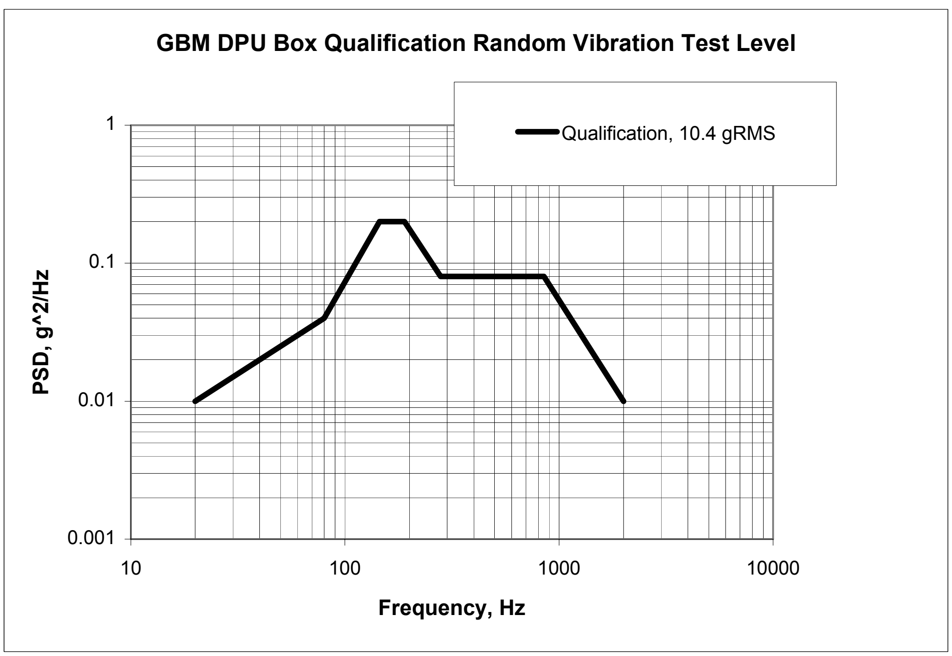


DPU
Acceptance Test Level

Frequency Hz	ASD g^2/Hz
20	0.01
80	0.04
145	0.1
190	0.1
280	0.04
850	0.04
2000	0.01
O/A	7.85

Duration: 60 secs/axis

CH-014



DPU
Qualification Test Level

Frequency Hz	ASD g^2/Hz
20	0.01
80	0.04
145	0.2
190	0.2
280	0.08
850	0.08
2000	0.01
O/A	10.4

Protoflight Duration: 60 secs/axis
Prototype Duration: 180 secs/axis

Figure 3-6 DPU Random Vibration Test Levels

3.2.2.8.4 Acoustics

The acoustic spectrum for the Delta II 2920H-10 launch vehicle (formerly known as the Delta II 7920H-10 launch vehicle) shall be used.

3.2.2.8.4.1 Acoustic Spectrum

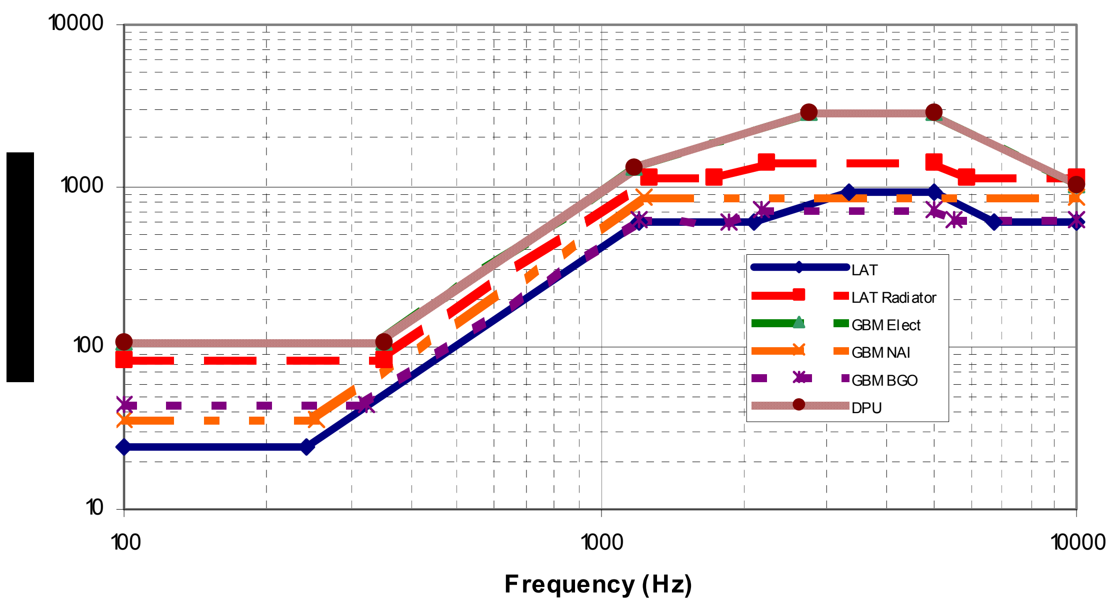
The appropriate acoustic spectrum shall be provided in the GLAST Spacecraft Performance Specification (433-SPEC-0003), as this data is not yet shown in the Delta II Payload Planners guide.

3.2.2.8.5 Pyroshock

CH-014

The payload shock response spectrum shall be as shown in Figure 3-7 : CH-02

Payload Shock Response Spectrum Protoflight Levels



CH-02

Figure 3-7 Payload Shock Response Spectrum CH-014

The tabular data used in construction of the figure is shown in Table 3-1 for reference: CH-014

Table 3-1 Payload Shock Response Spectrum

LAT		LAT Radiator		GBM Elect		GBM NAI		GBM BGO		DPU	
Freq (Hz)	SRS (g's)	Freq (Hz)	SRS (g's)	Freq (Hz)	SRS (g's)	Freq (Hz)	SRS (g's)	Freq (Hz)	SRS (g's)	Freq (Hz)	SRS (g's)
100	24	100	85	100	111	100	36	100	45	100	111
242	24	350	85	350	111	254	36	323	45	350	111
1201	606	1269	1127	1172	1295	1230	851	1202	624	1172	1295
2095	606	1724	1127	2757	2849	10000	851	1872	606	2757	2849
3342	932	2228	1427	5000	2849			2175	716	5000	2849
5000	932	5000	1427	10000	1036			5000	716	10000	1036
6715	606	5879	1127					5497	624		
10000	606	10000	1127					10000	624		

3.2.2.8.6 Finite Element Model

Finite element models of the GBM instrument major assemblies shall be delivered electronically to the GLAST Project Office at GSFC.

3.2.2.8.6.1 Finite Element Model Delivery

This delivery shall occur post-PDR on a date to be set by the GLAST Project Office at the GBM instrument PDR. The SC contractor will combine the GBM finite element models with a finite element model of the SC and perform a coupled loads analysis.

3.2.2.8.6.2 Finite Element Model Format and Units

The GBM finite element models shall be in NASTRAN format and use the SI system of units.

3.2.2.8.7 Sinusoidal Swept Vibration

CH-014

3.2.2.8.7.1 NaI Sine Vibration Levels

The evaluation of the NaI detectors shall use the acceptance and qualification sine vibration test levels shown in Table 3-3.

Table 3-3 NaI Sine Vibration Test Levels

Acceptance Test Levels		
Freq (Hz)	ATP (g)	Sweep Rate (Oct/Min)
5-16	0.5 in da	4
16-25	6.9	4
25-35	6.9	1.5
35-50	6.9	4

Qualification Test Levels			
Freq (Hz)	Qual (g)	Protoflight Sweep Rate Oct/Min	Prototype Sweep Rate (Oct/Min)
5-16	0.65 in da	4	2
16-25	8.6	4	2
25-35	8.6	1.5	2
35-50	8.6	4	2

Notes:

1. ¼ and/or ½ level sine vibration tests shall be performed before testing at full levels.
2. If necessary, the qualification sine vibration test input levels should be notched so that interface forces or response accelerations do not exceed flight loads predictions times 1.25.
3. If necessary, the acceptance sine vibration test input levels should be notched so that interface forces or response accelerations do not exceed flight load predictions.
4. The above levels shall be applied to three mutually perpendicular axes (two laterals and one axial).
5. The above specifications are appropriate for hard-mounted configurations of the NaI.
6. The 0.5” and 0.65” double amplitude displacements can be adjusted depending on the shaker capabilities.

3.2.2.8.7.2 BGO Sine Vibration Test Levels CH-014

The evaluation of the BGO detectors shall use the acceptance and qualification sine vibration test levels shown in Table 3-4.

Table 3-4 BGO Sine Vibration Test Levels

Acceptance Test Levels		
Freq (Hz)	ATP (g)	Sweep Rate (Oct/Min)
5-20	0.5 in da	4
20-25	10	4
25-35	10	1.5
35-50	10	4

Qualification Test Levels			
Freq (Hz)	Qual (g)	Protoflight Sweep Rate Oct/Min	Prototype Sweep Rate (Oct/Min)
5-20	0.65 in da	4	2
20-25	12.5	4	2
25-35	12.5	1.5	2
35-50	12.5	4	2

Notes:

1. ¼ and/or ½ level sine vibration tests shall be performed before testing at full levels.
2. If necessary, the qualification sine vibration test input levels should be notched so that interface forces or response accelerations do not exceed flight loads predictions times 1.25.

3. If necessary, the acceptance sine vibration test input levels should be notched so that interface forces or response accelerations do not exceed flight load predictions.
4. The above levels shall be applied to three mutually perpendicular axes (two laterals and one axial).
5. The above specifications are appropriate for hard-mounted configurations of the BGO.
6. The 0.5” and 0.65” double amplitude displacements can be adjusted depending on the shaker capabilities.

3.2.2.8.7.3 Power Box and DPU Sine Vibration Levels

The evaluation of the Power Box and DPU shall use the acceptance and qualification sine vibration test levels shown in Tables 3-5.

CH-014

Table 3-5 Power Box and DPU Acceptance Sine Vibration Test Levels

Acceptance Test Levels		
Freq (Hz)	ATP (g)	Sweep Rate (Oct/Min)
5-8	0.5 in da	4
8-25	1.8	4
25-35	1.8	1.5
35-50	1.8	4

Qualification Test Levels			
Freq (Hz)	Qual (g)	Protoflight Sweep Rate Oct/Min	Prototype Sweep Rate (Oct/Min)
5-8	0.65 in da	4	2
8-25	2.25	4	2
25-35	2.25	1.5	2
35-50	2.25	4	2

Notes:

1. ¼ and/or ½ level sine vibration tests shall be performed before testing at full levels.
2. If necessary, the qualification sine vibration test input levels should be notched so that interface forces or response accelerations do not exceed flight loads predictions times 1.25.
3. If necessary, the acceptance sine vibration test input levels should be notched so that interface forces or response accelerations do not exceed flight load predictions. CH-014
4. The above levels shall be applied to three mutually perpendicular axes (two laterals and one axial).
5. The above specifications are appropriate for hard-mounted configurations of the Power Box and DPU.
6. The 0.5” and 0.65” double amplitude displacements can be adjusted depending on the shaker capabilities.

3.2.3 THERMAL

3.2.3.1 GBM Thermal Design

The GBM thermal design shall be the responsibility of the GBM engineering team.

3.2.3.1.1 Passive Thermal System

The GBM shall employ a passive thermal system with heater control.

3.2.3.1.1.1 GBM Thermal System

The GBM thermal system shall be defined to include all GBM surfaces and thermal links that affect the GBM heat balance.

3.2.3.1.2 GBM Detectors

The thermal design for GBM detectors shall take into account the requirement for detecting the low energy gamma rays when designing the thermal insulation in front of the NaI detector beryllium windows.

3.2.3.1.2.1 On-Orbit Thermal Performance

GBM detector on-orbit thermal performance shall be the responsibility of the GBM instrument team.

NOTE 1: GBM NaI detector operating temperature range will be –15C to +45C . CH-014

NOTE 2: GBM BGO detector operating temperature range will be –5C to +30C . CH-014

NOTE 3: The rate of change for GBM detector temperatures will not exceed 8 C/hour.

NOTE 4: GBM NaI detector survival temperature range will be –15C to 50C. CH-014

NOTE 5: GBM BGO detector survival temperature range will be –15C to +30C. CH-014

3.2.3.1.2.2 Thermal Radiating Surfaces

3.2.3.1.2.2.1 Orientation

The orientation of each GBM detector thermal radiating surface in azimuth about the detector's normal vector shall maximize the surface's view to cold space and minimize heat back loading from the solar arrays, earth radiated, direct solar, and reflected solar energy.

NOTE: Nominal GBM detector thermal radiating surface orientations are depicted on the preliminary detector envelope drawings in the appendix.

3.2.3.1.2.2.2 Sizing

Each GBM detector thermal radiating surface shall be sized upon completion of the observatory coupled thermal analysis.

NOTE: Nominal GBM detector thermal radiating surface sizes are depicted on the preliminary detector envelope drawings in the appendix.

3.2.3.1.2.3 Thermal Isolation

The SC shall provide the thermal isolation of the GBM detectors.

3.2.3.1.2.3.1 Thermal Resistance

The thermal resistance from the SC structure to each detector shall be no less than 100 C/W.

3.2.3.1.2.3.2 Energy Flow

No more than a half-watt of energy flow shall be permitted between the SC and each GBM detector through cabling assuming worst-case temperature range limits of the GBM and SC. CH-014

3.2.3.1.2.4 GBM Detector Ground Operations

The SC shall satisfy the GBM NaI and BGO detector operating and survival temperature range requirements, and the GBM detector maximum temperature rate of change requirement as defined in requirement 3.2.3.1.2.1 during all ground operations. CH-014

3.2.3.1.2.5 Temperature Sensors

The GBM shall provide primary and redundant temperature sensors for each of the 16 PMTs. CH-03

NOTE: The SC continuously monitors all temperature sensors. CH-03

3.2.3.1.2.5.1 Temperature Sensor Mounting

The GBM shall mount primary and redundant temperature sensors in each of the 16 PMTs. CH-06

3.2.3.1.3 GBM Data Processing Unit (DPU) and Power Box

The GBM DPU and Power Box shall be mounted on SC structure.

3.2.3.1.3.1 Mounting Interface Thermal Control

The SC is responsible for providing thermal control at the GBM DPU and Power Box mounting interface based on temperature requirements and power dissipation characteristics specified in this document.

NOTE: Preliminary GBM DPU and Power Box orbit average power dissipations are 20 watts and 20 watts respectively including contingency.

3.2.3.1.3.2 Board Level Piece Part Thermal Analyses

The GBM instrument team is responsible for performing board level piece part thermal analyses to assure adequate heat transfer paths from the mounting interface to temperature sensitive components located within the electronics box.

3.2.3.1.3.3 Temperature Requirements

3.2.3.1.3.3.1 Maximum Operating Temperature

The maximum operational temperature of the GBM DPU and Power box shall not exceed +50°C.

3.2.3.1.3.3.2 Minimum Operating Temperature

The minimum operational temperature of the GBM DPU and Power box shall not be less than -20°C.

3.2.3.1.3.3.3 Survival Temperature

The minimum survival temperature for the GBM DPU and Power Box shall not be less than -30 C and the maximum survival temperature shall not exceed +70 C.

3.2.3.1.4 Environmental Parameters

Preliminary GBM thermal design shall use the environmental parameters of Table 3-2.

Table 3-2 Thermal Design Parameters

Thermal Flux Source	Hot Case	Cold Case
Solar Constant	1419 W/m^2	1286 W/m^2
Albedo Factor	0.40	0.25
Earth IR	265 W/m^2	208 W/m^2

3.2.3.2 Thermal Insulation

The design, fabrication, and delivery to the SC of all MLI for the GBM shall be the responsibility of the GBM instrument team.

3.2.3.3 Thermal Verification Requirements

The GBM thermal verification requirements at both the instrument and SC levels are specified in the GLAST Mission Assurance Requirements (MAR) for the GBM (433-MAR-0002).

3.2.3.4 Thermal Math Models

3.2.3.4.1 Detailed Thermal Math Models

3.2.3.4.1.1 Detailed GBM Sinda Model

The detailed GBM Sinda model shall be composed of a sufficient number of nodes to simulate key instrument heat flows, temperatures, and interface temperatures.

3.2.3.4.1.2 Detailed GBM Geometry Model

The detailed GBM geometry model used to calculate view factors and orbital absorbed heat shall be provided in TSS or TRASYS compatible format.

3.2.3.4.1.3 Detailed Thermal Math Model Deliveries

The detailed GBM Sinda and geometry models shall be delivered electronically to the GLAST Project Office FTP site.

3.2.3.4.1.3.1 Detailed Thermal Math Model Users Guide

A detailed thermal math model users guide shall be provided that describes thermal model nodal representations, key assumptions, and case descriptions.

3.2.3.4.2 Reduced Thermal Math Models

3.2.3.4.3 Reduced GBM Sinda Model

The reduced GBM Sinda thermal model (<25 nodes) shall provide similar results to the detailed GBM Sinda model in the areas of interface heat flow (both radiation and conduction) and average internal temperatures of major instrument components.

3.2.3.4.3.1 Reduced GBM Geometry Model

The reduced GBM geometry model used to calculate view factors and orbital absorbed heat shall be provided in TSS or TRASYS compatible format.

3.2.3.4.3.2 Reduced Thermal Math Model Deliveries

The reduced GBM Sinda and geometry models shall be delivered electronically to the GLAST Project Office FTP site for delivery to the SC and incorporation into the Observatory model.

3.2.3.4.3.2.1 Reduced Thermal Math Model Users Guide

A reduced thermal math model users guide shall be provided that describes thermal model nodal representations, key assumptions, and case descriptions.

3.2.4 ELECTRICAL

3.2.4.1 Power System

3.2.4.2 Average Power

The average power dissipation of the GBM instrument shall not exceed 105 Watts per orbit. CH-014

3.2.4.2.1 Peak Power

The GBM instrument's peak power shall not exceed 310 watts. CH-014

3.2.4.2.1.1 Peak Power Duration

The maximum duration for the peak power dissipation shall not exceed 5 minutes for each orbit.

NOTE: This peak power dissipation may take place at any time during an orbit and may take place in any number of intervals within the orbit.

3.2.4.2.2 Voltage

3.2.4.2.2.1 Operating Bus Voltage

The SC shall supply unregulated voltage of 28 (+7, -6) V at the GBM connector interfaces. CH-07

3.2.4.2.2.2 Survival Voltage

The GBM shall tolerate without damage or degradation DC voltages greater than 0 volts and less than 42.0 volts.

3.2.4.2.2.3 Voltage Transients

The GBM shall perform normally when subjected to voltage transients per CS116 requirements specified in the GLAST Observatory Electromagnetic Interference (EMI) Requirements Document (433-RQMT-0005).

3.2.4.2.3 Current

3.2.4.2.3.1 Overcurrent Protection

The SC shall provide overcurrent protection devices on each power connection to the GBM.

3.2.4.2.3.1.1 Ground Intervention

Ground intervention shall be required to reinstate power to the GBM if the overcurrent protection devices are activated.

3.2.4.2.3.2 Current Transients

The GBM shall limit current transients as specified in the GBM-SC ICD. CH-08

3.2.4.2.4 Impedance

3.2.4.2.4.1 Power Source Impedance

The impedance at the SC-GBM interface looking back at the SC source shall be as specified in the GBM-SC ICD. CH-08

3.2.4.2.4.2 GBM Power Input Impedance

The GBM power input filter shall present a symmetrical common mode and differential mode impedance to the power bus, as represented by the AC impedance of the differential mode and common mode input filters.

3.2.4.2.4.3 GBM Common Mode Impedance

The GBM common mode impedance shall be as specified in the GBM-SC ICD. CH-08

3.2.4.2.4.4 GBM Differential Mode Impedance

The GBM differential mode impedance shall be as specified in the GBM-SC ICD. CH-08

3.2.4.2.5 Primary Power Distribution

3.2.4.2.5.1 Definition of Feeds

The SC contractor shall provide one prime switched and one redundant switched power feed to the GBM.

3.2.4.2.5.2 Prime and Redundant Lines

The SC contractor shall provide prime and redundant power and returns for each feed to the GBM.

3.2.4.2.5.3 Prime and Redundant Line Exclusivity

The SC contractor shall provide prime and redundant services that are mutually exclusive in that only one is on at any time.

3.2.4.2.5.4 GBM Toleration of Simultaneous Power on Prime and Redundant Lines

The GBM shall tolerate, without damage or degradation to itself or the SC, prime and redundant power feeds that are active at the same time on any feed.

3.2.4.2.5.5 GBM Toleration of Power Interruption

The GBM shall tolerate instantaneous removal of power without warning and without damage or degradation to itself or the SC.

3.2.4.2.6 Survival Heater Power

3.2.4.2.6.1 Redundant Survival Heaters

The GBM shall have redundant survival heaters.

3.2.4.2.6.2 Redundant Power

The SC shall provide separate, redundant Survival Heater Power Buses and returns to each of the 12 NaI and 2 BGO detectors for the GBM survival heaters sized to provide a minimum of 6.4A total for all detectors. CH-13

NOTE: Survival power is used only for heaters and associated passive control circuitry that maintain the GBM at a minimum temperature.

3.2.4.2.6.3 Continuous Power to Heaters

The SC shall be capable of providing continuous power to the separate, redundant GBM Survival Heater Power Buses. CH-06

3.2.4.2.6.4 Heater Isolation

The GBM shall electrically isolate survival heaters from each other and from chassis.

3.2.4.2.6.5 Heater Power Returns

The GBM survival heaters shall have independent power returns.

3.2.4.2.6.6 Heater Power Consumption

The GBM's survival heater power shall not exceed 60 W, orbit average power. CH-014

3.2.4.2.6.7 Peak Heater Power Consumption

The GBM's survival heater power shall not exceed 224 W, peak power. CH-014

3.2.4.2.7 Isolation

The GBM shall provide secondary power converters that isolate secondary from primary power returns by > 1 MΩ at Direct Current (DC).

3.2.4.3 Grounding

The observatory shall employ a "hard-grounded" primary ground system with multiple connections in the secondary systems in accordance with the GLAST Observatory Electromagnetic Interference (EMI) Requirements Document (433-RQMT-0005).

3.2.4.3.1 Ground Reference

The SC shall provide a structure or an electrically conductive ground plane, known as chassis ground, as a ground reference.

3.2.4.3.2 Connection of the Power System to Ground

The primary power system shall be connected to chassis ground at a single point at DC by < 10 mΩ resistance and at AC by an impedance as specified in the GBM-SC ICD. CH-08

3.2.4.3.3 Chassis Current

The chassis ground system shall not be used to conduct load current.

3.2.4.4 EMI

Detailed requirements shall be documented in the GLAST Observatory Electromagnetic Interference (EMI) Requirements Document (433-RQMT-0005).

3.2.4.5 GBM Flight Harness

The SC shall provide a complete set of all GBM flight harnesses.

NOTE: The GBM flight harness will contain specialty configuration 1500-volt coaxial high voltage power and return lines to each of the 16 PMTs.

3.2.4.5.1 Primary and Redundant Lines

Primary and redundant lines (power feeds / signals) shall be routed via separate cables and connectors.

3.2.4.5.2 GBM Flight Harness Length

The flight harness length between the GBM's Data Processing Unit (DPU) and any other component (i.e. - GBM detector, solid-state recorder, etc.) shall not exceed 4 meters.

3.2.4.6 GBM Test Harness

The SC shall provide a complete set of all GBM test harnesses built to GBM flight harness design specifications, except for cleaning and bakeout. CH-09

3.2.4.7 C&DH Interfaces

This section describes the physical interface requirements for the C&DH services, which include the science data, command and telemetry, time mark and frequency and any discrete interfaces.

3.2.4.7.1 Interface Conductors

Signal conductors shall use paired conductors. Paired conductors may include twisted pair, coaxial, twin axial, dual coaxial, and triaxial types. CH-09

3.2.4.7.2 Interface Circuitry Isolation

The interface circuitry isolation shall be as specified in the GBM-SC ICD. CH-08

3.2.4.7.3 Physical Characteristics of Interface Signals

Physical characteristics of interface signals shall be documented in the SC-GBM ICD. CH-05

3.2.4.8 Test Point Interfaces

The SC or GBM may elect to use test points to provide external access to internal circuitry via GSE. Use of test points shall meet the following requirements.

3.2.4.8.1 SC Integration and Test Use

Test points shall not be used during SC integration and test, except as expressly approved and documented in formal procedures.

3.2.4.8.2 Performance Verification Limit

Data collected to verify acceptance or qualification of performance requirements shall be acquired through flight interfaces and not through test point interfaces.

3.2.4.8.3 Keyed Connectors

All test points shall be brought out to a separated, keyed or coaxial connector(s), which shall be easily accessible.

3.2.4.8.3.1 Separate Test Connectors

Separate test connectors shall be used to segregate classes of signals.

3.2.4.8.3.2 Connector Covers

When not in use and prior to launch, the connectors shall be protected with flight-qualified covers.

3.2.4.8.4 Power and Load Isolation

The observatory shall not be powered through, nor significantly loaded, by test point interface circuitry, including connection to external GSE.

3.2.4.8.5 Failure Propagation

Test point interface circuitry shall not propagate failures to flight circuitry. This includes credible failures in GSE connected externally to the test point interface connectors.

3.2.4.8.6 Short-Circuit Isolation

Test point short-circuit isolation shall also be provided. The observatory shall operate within specification in the event any test point is shorted to the power bus, ground, or another test point, and upon removal of the short.

3.2.4.8.7 Grounding Integrity

Test point interface circuitry shall not compromise grounding requirements, either by design or use.

3.2.4.8.8 Flight Standards

Test points shall be designed and implemented in accordance with all applicable flight standards and component ratings.

3.2.4.8.9 Test Point Documentation

Test point interfaces, functions and GSE interconnection shall be documented in the Interface Control Document for GBM.

3.2.5 COMMAND AND DATA HANDLING

3.2.5.1 Command, Telemetry, and Data Bus (CTDB)

3.2.5.1.1 CTDB Specification

Commands, telemetry, time messages, and ancillary data shall be transferred between the GBM and the SC C&DH via a serial CTDB compliant with MIL-STD-1553B.

3.2.5.1.2 CTDB Protocol

The CTDB data shall utilize the communications protocol at the physical layer as defined by MIL-STD-1553B.

3.2.5.2 Time Support

3.2.5.2.1 Pulse Per Second (PPS) Bus

The SC shall provide the GBM a 1 PPS signal accurate to ± 1.5 microseconds across an LVDS interface. CH-03

3.2.5.2.2 GPS Receiver Time Dropout

The PPS signal shall be provided without interruption to the GBM in the event of a loss of the time signal provided by the GPS receiver.

3.2.5.2.3 PPS Signal Drift

The 1 PPS signal shall not drift more than $\pm$ 1μsec over 100 seconds. CH-03

3.2.5.3 Control and Monitoring

3.2.5.3.1 Analog Signals

The SC shall provide 26 primary and 26 redundant analog channels for monitoring GBM health and safety. CH-05

3.2.5.3.2 Analog Signal Sampling

3.2.5.3.2.1 Analog Sampling Rate

The instrument analog signals shall be sampled at a rate not to exceed 5 Hz.

CH-09

3.2.5.3.2.2 Analog Sample Reporting

The instrument analog data shall be included in housekeeping telemetry at a rate between 0.01 Hz and 5 Hz.

3.2.5.3.2.3 Analog Sampling Resolution

The instrument analog signals shall be sampled at a resolution not to exceed 12 bits.

3.2.5.3.3 Discrete Control Signals

The C&DH shall provide 4 primary and 4 redundant discrete pulse signals channels for configuration and power control of the GBM. CH-04

3.2.5.3.4 Deleted CH-11

3.2.5.4 Science Data Interface

3.2.5.4.1 High-Speed Serial Interface

The GBM-SC data rate on the dedicated science data interface shall accommodate data transfer rates up to a maximum rate of 12 Mbps.

3.2.5.4.1.1 GBM to SC Interface Transmitters and Receivers

The GBM-SC interface transmitters and receivers shall use LVDS drivers and receivers compatible with IEEE 1596.3SCI LVDS and be compatible with ANSI/TIA/EIA 644-1996 LVDS standards.

NOTE: High level protocols such as IEEE-1335 and IEEE-1394 are not acceptable implementations of this interface. The details of the protocol will be defined in the GBM-SC ICD. CH-03

3.2.5.4.1.2 Maximum Signal Frequency

The maximum signal frequency of any one interface signal shall be 1.5 MHz for an 8 bit bus. CH-03

3.2.5.4.1.3 GBM to SC Interface Configuration

The GBM-SC interface shall have 1 instrument provided clock signal, 8 data bits, and 1 instrument provided data valid signal from the GBM to the SC. CH-03

3.2.5.4.1.4 Science Data Interface Redundancy

CH-03

The science data interface shall provide cross-strapping redundancy between the spacecraft and the instrument. (I.e. Both Side A and Side B of the instrument interface to both Side A and Side B of the SC.)

3.2.5.4.2 Packet Format

All GBM science data transferred over the high rate bus shall be CCSDS Source Packets as defined in 102.0-B-4 (Packet Telemetry Blue Book).

3.2.5.4.3 Packet Size

The GBM shall utilize variable length CCSDS source packets up to a maximum length of 65536 octets.

3.2.5.4.4 Data Volume

The SC shall provide 2.2 Gigabits of storage for GBM data over a 24-hour period.

3.2.5.4.5 CCSDS Packet Synchronization Marker

Each CCSDS Source Packet shall have a 32-bit sync pattern pre-pended to the packet. CH-03

Note: This sync pattern facilitates subsequent data packet reconstruction.

3.2.6 SOFTWARE

3.2.6.1 Commands

3.2.6.1.1 CTDB (1553) Command Data

All 1553 commands issued by the SC to the GBM shall be documented in the SC-GBM ICD.

3.2.6.1.1.1 GBM Table Loads

The GBM shall load internal tables from commands issued by the SC (from the ground).

3.2.6.1.1.2 GBM Memory Loads

The GBM software shall be reprogrammable via software load commands.

NOTE: This includes loading patches into RAM, and also reprogramming EEPROMs in the GBM.

3.2.6.1.1.3 GBM Configuration Commands

The GBM shall be configured by commands issued by the SC.

3.2.6.1.2 GBM Command Frequency

The SC shall transmit commands to the GBM at a maximum rate of 20 telecommands per second. CH-03

3.2.6.1.3 Memory Load Rate

Memory loads shall be provided to the GBM at a rate consistent with the SC C&DH.

3.2.6.2 Telemetry

3.2.6.2.1 CTDB (1553) Telemetry Data

All 1553 telemetry packets from the GBM to the SC shall be documented in the SC-GBM ICD.

3.2.6.2.2 GBM Housekeeping Data

The GBM shall provide the SC, upon request, a housekeeping data set as defined in the SC-GBM ICD.

3.2.6.2.3 Application Identifier (APID) Allocation

The GBM shall utilize APIDs as defined in the GBM section of the SC-GBM ICD.

3.2.6.2.4 GBM Memory Dumps

Both GBM program memory and data memory, as well as any logs maintained in the instrument may be dumped by command.

3.2.6.3 Time Messages

3.2.6.3.1 Distribution Format

The SC shall issue a time message that gives a “time at the tone will be message” in GPS time format.

3.2.6.3.2 Distribution Timing

The Time Mark Message shall be issued 500 milliseconds or more before the transition of the1 PPS time mark signal.

CH-03

3.2.6.4 Ancillary Data

The SC shall provide an ancillary data packet to the GBM at the rate of one/second or greater.

3.2.6.4.1 Ancillary Data Packet CH-08

The ancillary data packet shall contain data as specified in the GBM-SC ICD.

3.2.6.5 Event Data Reporting

With each occurrence of a burst trigger, the GBM shall generate messages described below. CH-08

3.2.6.5.1 Burst Trigger Interval

The interval between successive burst triggers shall be as defined in the LAT-GBM ICD.

3.2.6.5.2 Immediate Trigger Signal CH-08

The GBM shall send a single pulse to the LAT (via the SC harness) for each burst trigger in the GBM across an LVDS interface. CH-03

3.2.6.5.2.1 Immediate Trigger Signal Redundancy

The Immediate Trigger Signal LVDS interface shall provide cross-strapping redundancy between the GBM and the LAT. (i.e. Both Side A and Side B of the GBM interface to both Side A and Side B of the LAT.) CH-08 CH-04

3.2.6.5.3 Telecommands to the LAT

For each burst event, the GBM shall provide to the LAT a series of telecommands over the CTDB bus as described in the LAT-GBM ICD.

CH-08

3.2.6.5.4 Burst Alert Telemetry

For each burst event, the GBM shall send alert telemetry to the SC for transmission to the ground as defined in the LAT-GBM ICD.

3.2.7 FAULT PROTECTION

3.2.7.1 Safe Mode Notification

The SC shall notify the GBM across the CTDB when entering safe mode. CH-06

NOTE: The SC will enter safe mode when a mission critical fault is detected and cannot be corrected by on-board processes.

3.2.7.2 Load Shedding

GBM power shall be disconnected when ground-based or on-board fault analysis determines load shedding is required.

3.2.7.2.1 Load Shedding Notification

The SC shall send a message to the GBM across the CTDB no less than 15 seconds prior to issuing a command to disconnect GBM power.

3.2.8 MAGNETIC FIELD

None of the GBM detectors shall be exposed to an onboard generated magnetic field of greater than one gauss.

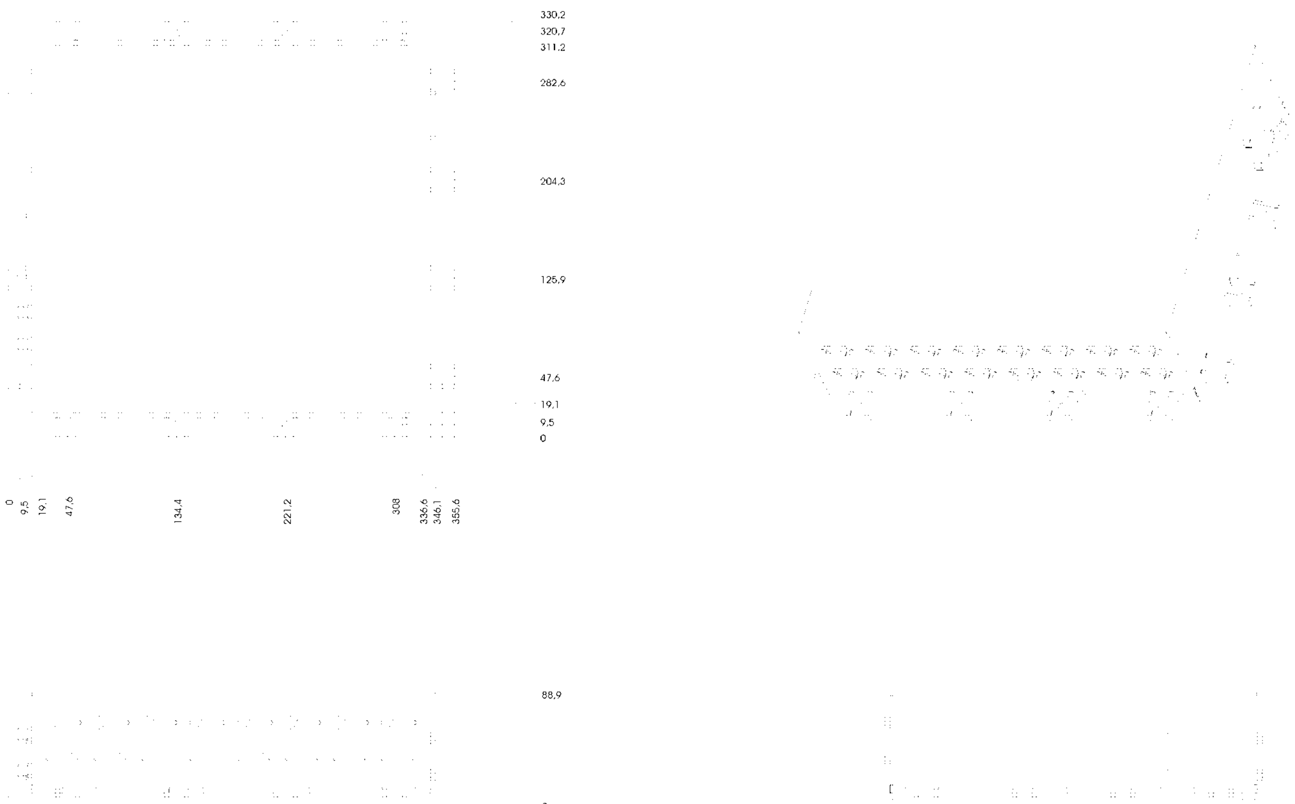
4 DEVIATIONS/WAIVERS

4.1 PRIMARY AND REDUNDANT LINES

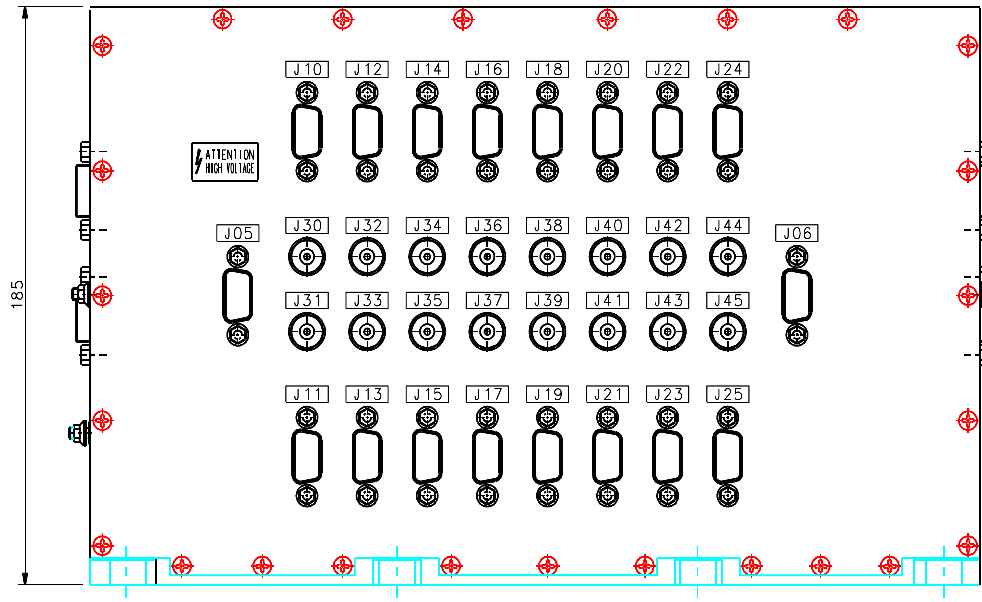
CH-10

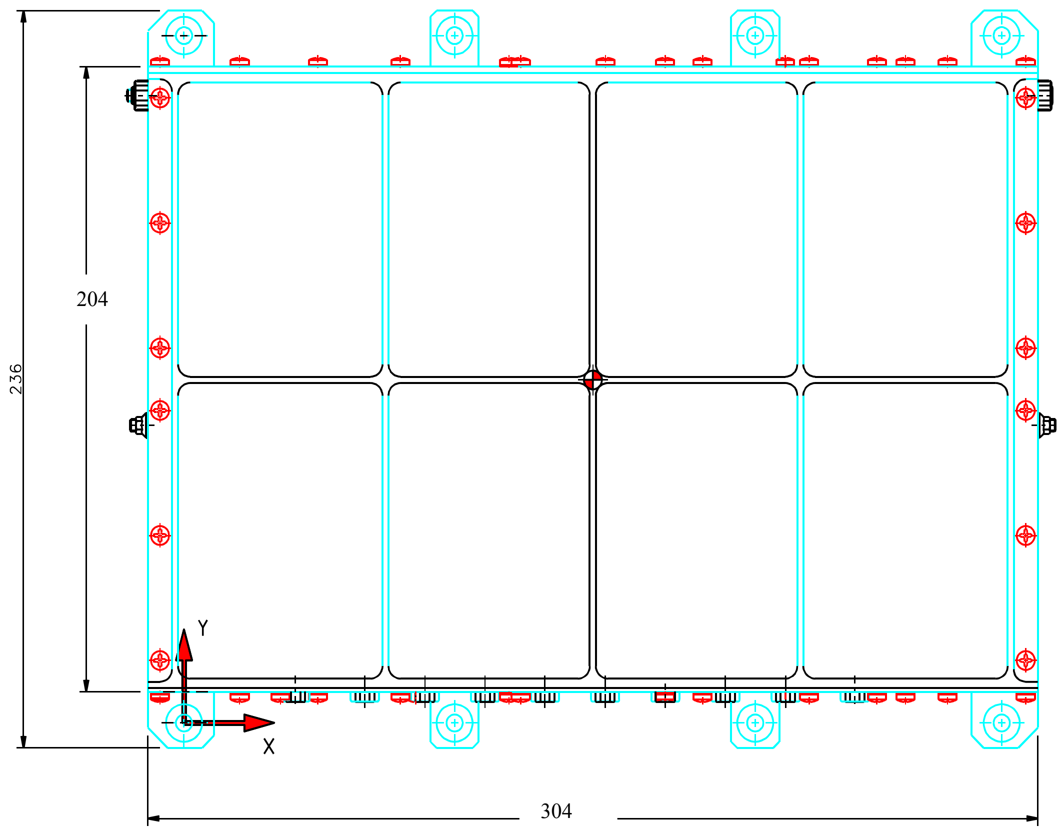
A waiver to the GBM IRD paragraph 3.2.4.5.1 Primary and Redundant Lines, has been approved. This waiver allows the GBM to route the survival heater power and thermistor monitors to the detectors via the same cables and connectors.

APPENDIX CH-10



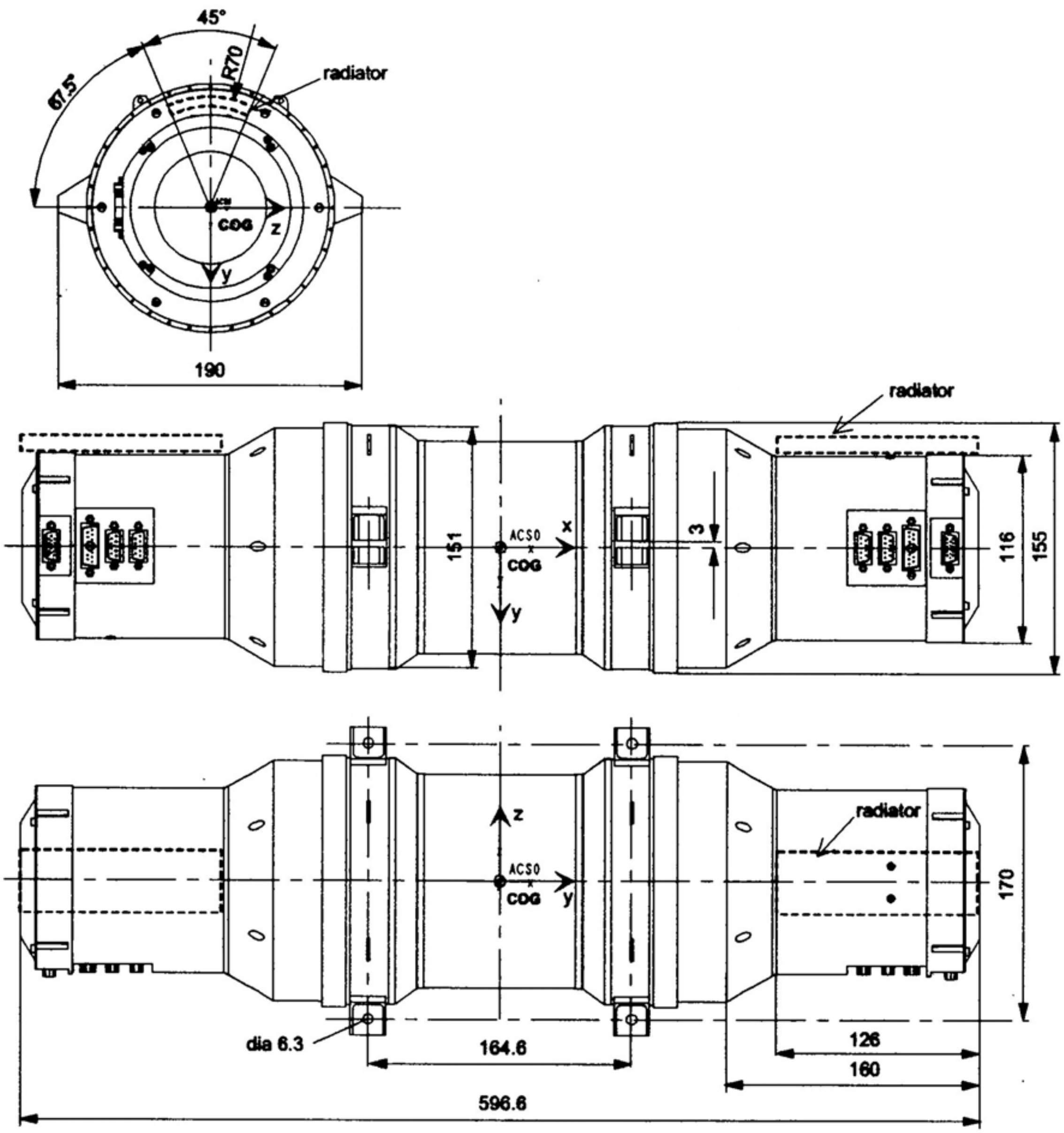
Preliminary Data Processing Unit (DPU) Envelope Dimensions (mm)



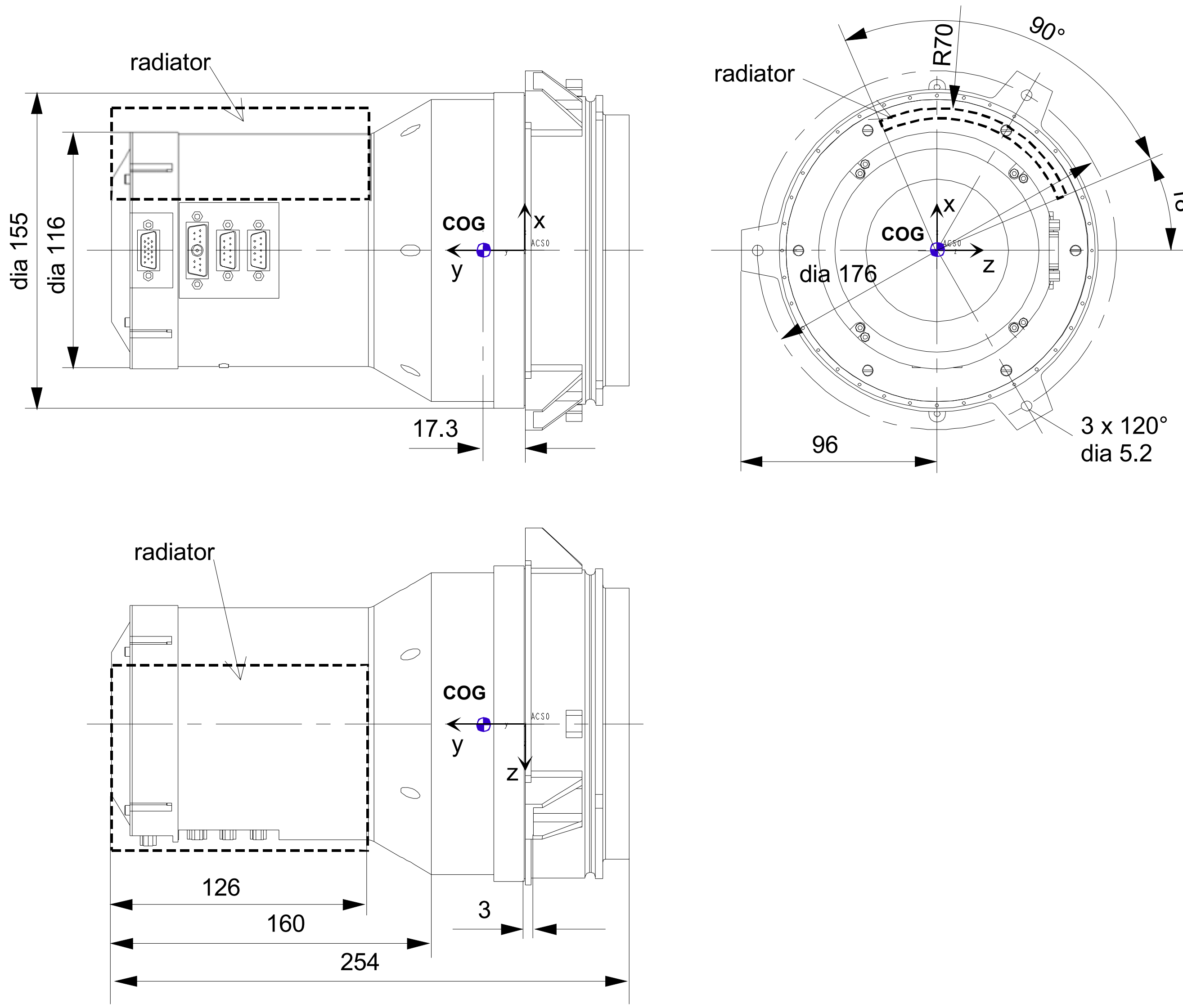


Preliminary Power Box Envelope Dimensions (mm)

CHECK THE GLAST PROJECT WEBSITE AT
http://glast.gsfc.nasa.gov/project/cm/mcdl TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.



Preliminary BGO Detector Envelope Dimensions (mm)



Preliminary NaI Detector Envelope Dimensions (mm)